Supporting information

Reinforced Concrete Structure rGO/CNTs/Fe_2O_3/PEDOT:PSS Paper Electrode with excellent wettability and flexibility for Supercapacitors

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Experimental Procedures

Materials and Characterization

Ferric nitrate, methanol and ammonium hydroxide are purchased from Aladdin. Ethanol, vitriol, rGO are purchased from Tianjin recovery technology development Co., Ltd. (Tianjin, China). Poly(3,4-ethylenedioxothiophene) -poly(styrenesulfonate) (PEDOT: PSS) is purchased from Gold leaf electronics Co., Ltd. (Shenzhen, China). All chemicals used in this study are analytical grade. Powder XRD patterns are obtained on a Bruker D8 Focus (Germany) diffractometer using Cu Kα radiation (λ = 0.15418 nm). Sample morphologies are observed by SEM using a Rigaku S-4300 (Rigaku, Tokyo, Japan) spectrometer with an energy dispersive spectrometer (EDS). The microscopic features of the samples are observed by TEM using a Rigaku H-7650 electron microscope at 100 kV. HRTEM images are obtained using a Tecnai G2 transmission electron microscope (USA) operated at an accelerating voltage of 200 kV. X-ray photoelectron spectroscopy (XPS) measurements are recorded on an RBD upgraded PHI-5000C ESCA system (PerkinElmer) with Al Kα radiation (hυ = 1486 eV).

Electrochemical Measurement

The rGO/CNTs/Fe_2O_3/PEDOT:PSS composite paper is tailored and applied to working electrodes (1 cm× 1.5 cm, effective worked area of 1 cm × 1 cm). A platinum foil (10 mm × 10 mm) is employed as the counter electrode and SCE (saturated calomel electrode) as reference electrode, which apply to a three-electrode system in 3 M KOH solution. The CHI 660D electrochemistry workstation is used to the electrochemical measurements. Cyclic voltammetry (CV) tests are conducted in a potential range of -1−1 V (versus SCE) at scan rates of 10-100 $mV\cdot s^{-1}$. The cycling behavior is particularly pronounced to 10000 cycles, and galvanostatic charge–discharge (GCD) tests are carried out at various current densities with a potential range of 0−2 V (versus SCE). EIS (Electrochemical impedance spectroscopy) is implemented to testify the capacitive property at OCV (open circuit voltage) with a frequency from 1 to 10^5 Hz.

The symmetric supercapacitors are assembled with rGO/CNTs/Fe_2O_3/PEDOT: PSS composite paper as positive electrode and negative electrode. The two electrodes of the symmetric flexible supercapacitor are separated by a separator (NKK, MPF30AC-100), and 3 M KOH is used as the electrolyte. The Formula for calculating the mass specific capacitance of a single electrode is $Cm = I\cdot\Delta t/m\cdot\Delta V$ (F1) and the area specific capacitance of a single electrode is $Cs = I\cdot\Delta t/s\cdot\Delta V$ (F2). The area ratio of two electrodes is decided in accordance with the charge balance equation ($q+ = q-$). To achieve this, the area of the electrode materials is balanced in accordance with the equation: $Cs = I\cdot\Delta t/2s\cdot\Delta V$ (F3) and the volume specific capacitance of a cell is $Cv = I\cdot\Delta t/v\cdot\Delta V$ (F4), this Cs is the area specific capacitance, Cv is the volume specific capacitance, I is current density, Δt is discharge time, s is area of electrode materials, v is volume of a cell and ΔV is the voltage range of positive - negative voltage, respectively. The specific energy density E and power density P are defined as E =1/2

Cm(ΔV) ^{2}(F5) and P = E/Δt (F6).

Results and Discussion

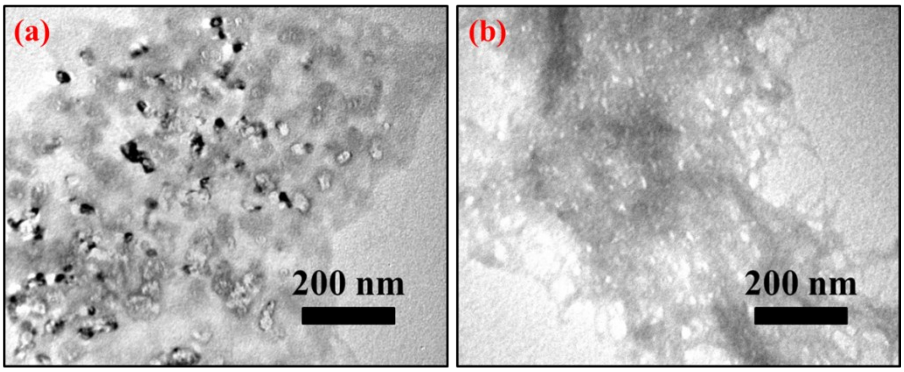


Figure S1. TEM images of (a) PEDOT: PSS solution, (b) PEDOT: PSS film.

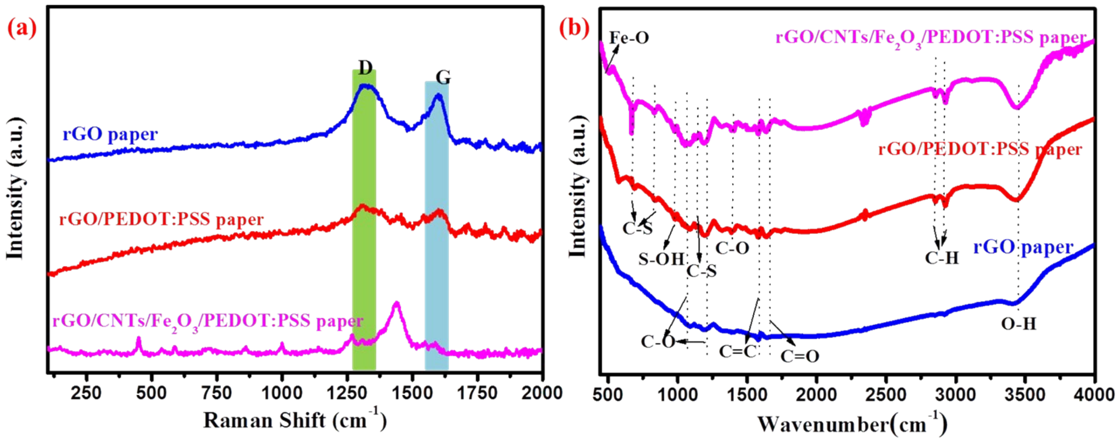
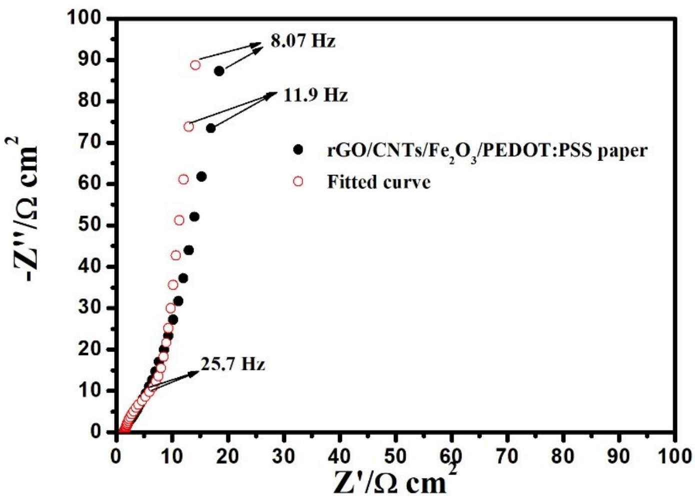


Figure S2. (a) Raman spectra and (b) FTIR spectra of rGO paper, rGO/PEDOT:PSS paper and rGO/CNTs/Fe_2O_3/PEDOT:PSS composite paper.



FigureS3. Impedance curve and fitting curve of rGO/CNTs/Fe_2O_3/PEDOT:PSS composite paper

Figure S4. The cross section SEM and the corresponding elemental mapping images of rGO/CNTs/Fe_2O_3/PEDOT:PSS paper.

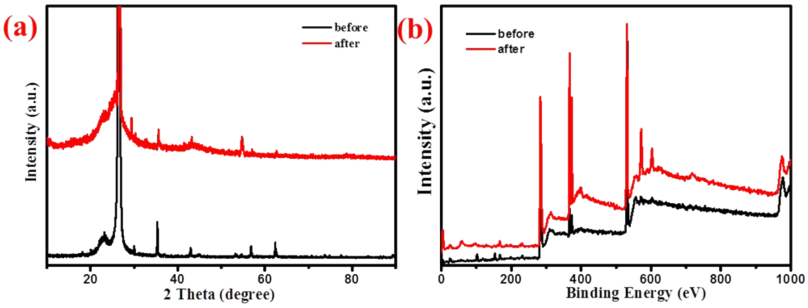


Figure S5. (a, b) XPS and XRD patterns of rGO/CNTs/Fe_2O_3/PEDOT:PSS paper before and after 10000 cycles.

Table1. Comparisons of specific capacitance, energy density and power density of PEDOT:PSS and rGO based supercapacitors.

Material	**Specific capacitance**	**Energy Density**	**Power Density**	**Voltage**	Ref.
Co_9S_8/PEDOT:PSS/rGO	788.9 F g^{-1} at 1A g^{-1}	19.6 Wh kg^{-1}	400.9 W kg^{-1}	1.6 V	20
$Ti_3C_2T_x$/rGO	313 F g^{-1} at 1 A g^{-1}	7.5 Wh kg^{-1}	500 W kg^{-1}	1.0 V	35
VO_2(B)/CNT/rGO	649.1 F g^{-1} at 0.5 A g^{-1}	32.5 Wh kg^{-1}	3000 W kg^{-1}	1.2 V	47
PEDOT:PSS@$CoFe_2O_4$	181.3 F g^{-1} at 1 A g^{-1}	25.17 Wh kg^{-1}	620.6 W kg^{-1}	2.0 V	48
CNTs/PEDOT	147 F g^{-1} at 0.5 A g^{-1}	12.6 Wh kg^{-1}	10200 W kg^{-1}	1.4 V	49
rGO/PEDOT/PANI	535 F g^{-1} at 1 A g^{-1}	26.89 Wh kg^{-1}	800 W kg^{-1}	0.8 V	50
GP@NiO	306.9 F g^{-1} at 0.5 A g^{-1}	17.6 Wh kg^{-1}	0.25 kW kg^{-1}	1.0 V	51
rGO/Fe_2O_3/CNTs/PEDOT:PSS	997 F g^{-1} at 1 A g^{-1}	35.6 Wh kg^{-1}	166 W kg^{-1}	1.6 V	This work